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Evaluation of Corrosion Resistance of IVD Coatings on E40CDV20 Steel Fasteners

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Abstract: ***Different types of fasteners are used in aerospace applications. E40CDV20 is a high strength hardened tempered steel. For high strength fasteners, different types of coatings are used for improving surface protection and achieving desired mechanical and surface properties. Evaluation of corrosion resistance of aluminium IVD which is used for high strength alloy steel fasteners has been carried out in this paper. Fasteners made out of high strength alloy steel materials namely E40CDV20 is used in this study. Scanning electron microscopy is done to evaluate the morphology of the coating. Salt spray test is conducted for the evaluation of corrosion resistance of aluminium IVD of coatings on E40CDV20 steel fasteners.***

Keywords: High strength fasteners, Aluminium IVD coating, E40CDV20, SEM, Salt spray test

1. Introduction

Fasteners are defined as hardware that can be easily installed and removed with hand or power tools. Screws, bolts, nuts and rivets are common types of fasteners. There is no one fastener material that is right for every environment. Selecting the right fastener material from the vast array of materials available can appear to be a daunting task. Careful consideration may need to be given to strength, temperature, corrosion, vibration, fatigue and many other variables. Most of the fasteners are coated with different kind of materials using different processes to improve their functional properties. In many cases, special coatings or plating may be applied to metal fasteners to improve their performance characteristics like mechanical and surface properties. Common coatings/platings include electrolytic plating, hot-dip coating and mechanical plating. Cadmium coating provides excellent corrosion protection but this process is harmful for environmental conditions due to forming toxic products.

Evaluation of corrosion resistance of aluminium IVD which is used for high strength alloy steel fasteners has been carried out in this paper. Ion Vapor Deposition (IVD) is a physical vapor deposition process for applying pure aluminum coatings to various substrates, the parts, mainly for corrosion protection. The process is applied in a vacuum vessel of various sizes, called an Ivadizer. To prevent contamination of the pure aluminum coating from oxygen and water vapor in the atmosphere, the aluminum coating is applied to the substrates in a vacuum. Its useful service temperature limit is 925ºF. Because the process must be done in a specially designed vacuum chamber, it is quite expensive. It creates no hydrogen embrittlement and no toxic byproducts. Aluminium IVD process is done as per AMS 2427 standard. Fasteners made out of high strength alloy steel materials namely E40CDV20 is used in this study. Important properties of E40CDV20 steel are: Highly temperature and highly strength up to approx. 500°c, Not corrosion resistant, low tendency to distortion , limited weldable scaling possible already at 500ºC.

In this paper evaluation of corrosion resistance of aluminium IVD which is used for high strength alloy steel fasteners has been carried out. Salt spray test is conducted on M27 and M10 bolt made of E40CDV20 material.

2. Experimental Details

2.1 Test specimen

Salt spray test is conducted on M27*2.00*77 Aluminium IVD coated and M10*1.25*35 aluminium IVD coated HSHCB made of E40CDV20 high strength alloy steel as per procedure ASTM B117. Microstructural analysis is done using SEM. Coating thickness of IVD coated fastener is measured using optical microscope. E40CDV20 is a high strength hardened tempered steel. Table [1] shows the chemical composition of E40CDV20 alloy steel. Figure [1] shows the image of test specimen.

Table 1: Chemical composition of E40CDV20

Element	%composition
C	0.37-0.44
Si	0.8-1.00
Mn	0.2-0.5
Cr	4.75-5.25
Mo	1.20-1.40
V	0.40-0.60
S	≤0.010
P	≤0.015

Figure 1: Test specimen

2.2 Aluminium IVD coating

Ion Vapor Deposition (IVD) is a physical vapor deposition process for applying pure aluminum coatings to various parts for corrosion protection. A vacuum vessel of various sizes, called an Ivadizer is used for coating process. Figure [2] shows the flow chart of aluminium IVD coating process.

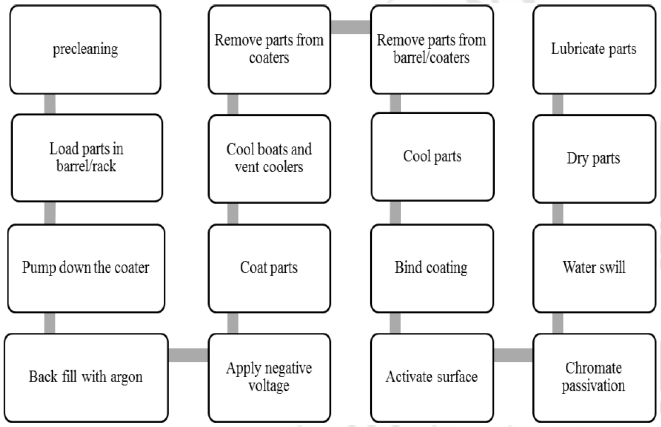


Figure 2: Flow chart of Aluminium IVD coating

2.3 Experimental set up for salt spray test

Test specimens are placed in an enclosed chamber and exposed to a continuous indirect spray of salt water solution (also referred to as fog or mist) which falls-out on to the specimens at a rate of 1.0 to 2.0 ml/80cm²/hour, in a chamber temperature of 35°C. The pH of the salt solution fall-out should be maintained at a neutral pH ((pH 6.5 to 7.2 – this is also commonly referred to as NSS, which stands for Neutral Salt Spray). The chamber climate is maintained under constant steady state conditions. The test duration is variable. For aluminium IVD coated fasteners test duration is 168 hours. Figure [3] shows salt spray apparatus as per ASTM B117standard.

Figure 3: Salt spray apparatus

2.4 Microstructure analysis

A section of the sample was ground with a series of emery papers down to 600 grit size and polished with diamond paste of 1-2 micron size. It was etched with nital. Micro structure analysis is done using scanning electron microscope (SEM) to check whether the fastener surfaces are free from defects. Figure [4] shows the image of SEM.

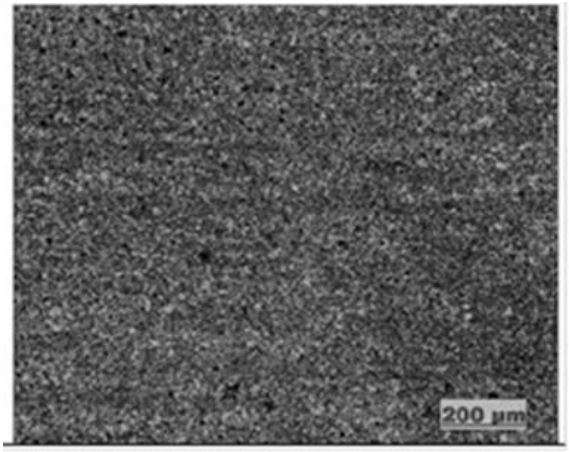
Figure 4: Scanning electron microscope

2.5 Results and discussion

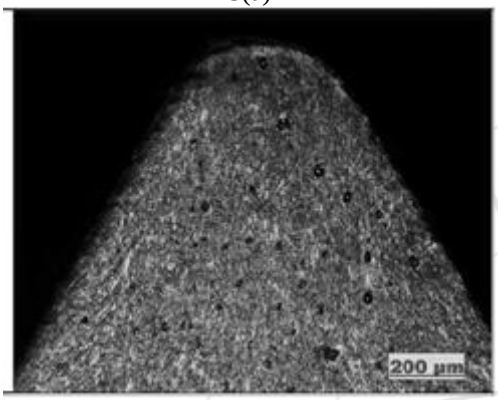
The test results of M27 and M10 Aluminium IVD coated HSHCB are given in table [2]. Figure [5] shows the microstructural images of M27*2.0*77 Aluminium IVD coated HSHCB. Figure [6] shows the microstructural images of M10*1.25*35 aluminium IVD coated HSHCB.

Table 2: Results of salt spray test

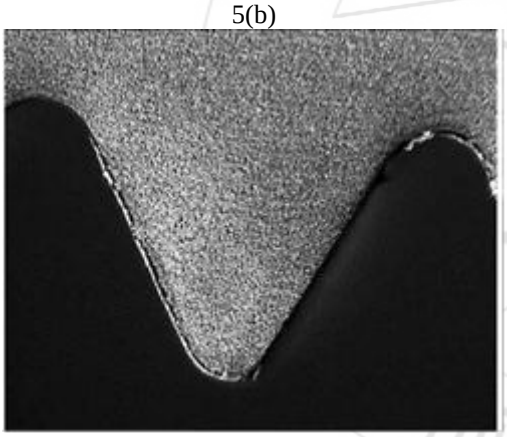
Test specimen	Sample size	observation
M27*2.00*77 Aluminium IVD coated HSHCB	10	Total time of exposure :168 hours Result :No corrosion after 168 hours of testing and part found ok
M10*1.25*35 Aluminium IVD coated HSHCB	10	Total time of exposure :168 hours Result :No corrosion after 168 hours of testing and part found ok



5(a)

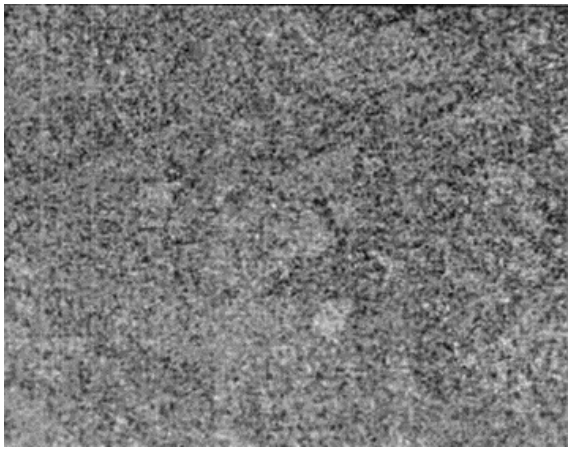


5(b)

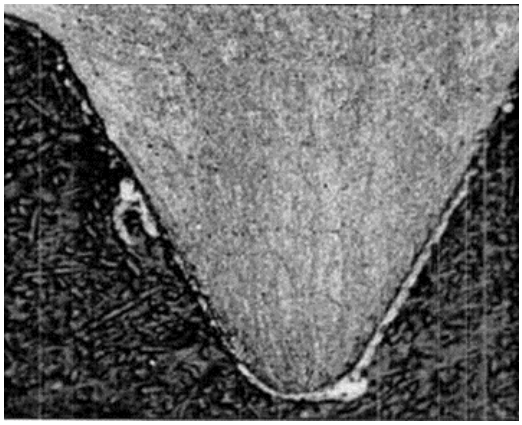


5(c)

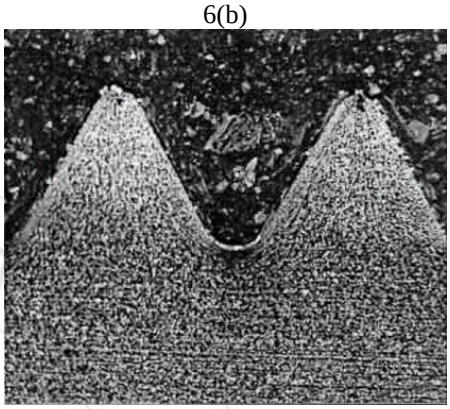
Figure 5(a), (b), (c): Microstructural analysis of M27 HSHCB



6(a)



6(b)



6(c)

Figure 6(a), (b), (c): Microstructural analysis of M10 HSHCB

From the results of salt spray test is conducted on M27*2.0*77 and M10*1.25*35Aluminium IVD coated and cadmium IVD coated HSHCB made of E40CDV20 it is found that the parts obey the specification of test methods. According to the specification of salt spray test of aluminium IVD coated fastener after 168 hours of exposure to salt spray test there shall not more than the following: 15 scattered spots or pits of 0.8mm dia max. in 150 in 2 of test areas from five or more specimens and 5 scattered spots or pits of 0.8mm dia max. in 30 in 2 areas of one or more specimens. The microstructure is fine and uniform across the section of IVD coated E40CDV20 fasteners. Free from Surface decarburization, inclusion, burns, cracks and voids.

3. Conclusions

Various types of coating used in aerospace fasteners namely electrolytic cadmium plating, Aluminium IVD coating and vacuum deposition of Cadmium are studied. Evaluation of corrosion resistance of the IVD coating are done by salt spray test and microstructural analysis using SEM on E40CDV20 fasteners. During salt spray test there is no corrosion for base material after 168 hours for aluminium IVD coating. The microstructure is uniform, fine and free from corrosion and surface cracks. From the results concluded that aluminium IVD coating provides better corrosion resistance for high strength fasteners like E40CDV20 alloy steel.

4. Acknowledgement

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